Average factor (f.) to reduce Callendar to Marvin

1913–1915	0.0346	0.0342	0.0354	0.0380	0.0423	0.0502
1917	.0353	.0354	.0377	.0371		
1927	.0354	.0356	.0358	.0381	.0418	.0489

Standard deviation of the observations of f.

1913–1915	0.0010	0.0018	0.0018	0.0024	0.0017	0.0015
1917	.0011	.0010	.0019	.0038		
1927	.0020	.0013	.0023	.0031	.0051	

Standard error of the mean f. in each group

1913–1915	0.0003	0.0005	0.0005	0.0017	0.0017	0.0015
1917	.0004	.0004	.0010	.0022		
1927	.0007	.0002	.0005	.0008	.0026	

Increase of f.

1913–1915 to 1917	*0.0007*	0.0012	0.0023	0.0009		
1913–1915 to 1927	.0008	.0014	*.0004*	*.0001*	0.0005	
1917 to 1927	.0001	*.0002*	.0019	.0010		

The best value of the change of f. in each column, i. e. the one obtained from the means having the smallest standard error at both beginning and end of the interval, is indicated by italicizing. It will be observed that these changes are mostly smaller than the standard errors of the means on which they are based, whereas the differences should be three times as large as the standard errors to indicate progressive change, with certainty.

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DISCUSSION

It is a source of gratification that further comparisons between the Marvin and the Callendar pyrheliometer in use at Madison cast doubt upon a possible deterioration in the Callendar instrument, which earlier comparisons seemed to indicate. On account of the small number of these comparisons in the different periods compared, this point can not be considered definitely settled, however. It is therefore hoped that additional comparisons may be obtained from time to time.

I may add that similar comparisons that are obtained during nearly every month at Lincoln, Nebr., have not shown an appreciable change in the reduction factor for the Callendar pyrheliometer in use at that station, except on one occasion, when the bridge wire was injured and had to to be replaced.

Mr. Miller's paper shows quite conclusively that the progressive diminution in the annual totals of radiation received at Madison is attributable to the increased smokiness of that part of the city in which the university and the Weather Bureau are located, due to the change from anthracite to bituminous coal for heating dwellings, and an increase in the number of dwellings in the university section of the city. The same thing is true at the American University, District of Columbia, where, also, the depletion is confined to the winter months.—*H. H. Kimball.*

THE FUTURE OF AGRICULTURAL METEOROLOGY

By W. A. MATTICE

[Weather Bureau, Washington, August, 1931]

In these days of overproduction of agricultural products, with a corresponding depression of prices, the thoughts of the Nation turn to the plight of the farmer. There are many experiment stations, experimental farms, and various governmental agencies that are continually advising the farmer what crops to grow and what crops not to grow, but has the weather received full consideration in these opinions? The ever-present alchemist that transmutes base materials into the gold of the ripe wheat, corn, etc., has been scarcely accorded the measure of respect due the vast power wielded. The weather in its effect on agriculture has been scrutinized from afar, as through a long-range telescope, but very little has been accomplished in pursuing the microscopic detail necessary for complete understanding of the underlying principles involved in crop growth. The experimenter in physics, for example, does not attack his problems with the pick and shovel of the day laborer, but with intricate machinery, delicate lenses, accurate micrometers, etc. The comparison is perfectly analogous, for the present-day researches in agricultural meteorology are conducted on a grand scale, a State unit, district unit, or even a country-wide unit. The wealth of detail obtainable on such scales are meager, it is indeed, comparable to the pick and shovel of the day laborer. We might as well supply the archeologist with dynamite alone and expect him to return with the delicate murals, friezes, urns, etc., that are obtained only through infinite patience and careful brushing and screening of minute fragments.

Statistical studies of crop production as related to weather conditions have been and are still being made, with variable results. It is the present experience of investigators that, a series of correlations reaching a coefficient of 0.90, or a little better, is about as good as can be expected with available crop and weather data. However, a coefficient of 0.90 leaves much to be desired, for even with one this high there still remains 43 per cent of the spread between the actual and computed figures to be accounted for outside the data included in the equations. How can this gap be bridged; and is the inadequacy of the data the stumbling block?

The Weather Bureau includes in its meteorological statistics for first-order stations, in addition to temperature and rainfall, the hours of sunshine, direction of the wind, state of the weather, barometric pressure, vapor pressure, relative humidity, etc. Perhaps these, or at least some of them, have important relations to crops, but what material benefit are they when measured on the top of an office building sometimes four or five, or even more, miles from the nearest crops? Again, these first-order stations are widely separated—they are seldom nearer than 50 miles from each other and the various States rarely have over six or seven of them. What variations in the weather occur between them?

The cooperative stations are nearer the crops, being mostly in small towns, or even on farms, in some instances, but they measure only rainfall and temperature once a day and have no self-recording instruments that keep a continuous record. Thus, for these which are more directly applicable, many weather phases are not available.

The crop statistics are even more hazy and generalized, in addition to being relatively inaccessible. We can find easily the estimated yield per acre or total acreage, for the most available data give these figures on a State unit basis, but yields often vary widely in different parts of a State. Local, even in most places county, temperature and rainfall data are available, but what about corresponding yield figures? They are to be had in some individual State publications, but a complete file for one State is difficult to find outside the issuing office and then the series is rarely carried back far enough to be of material value for study purposes. Even if county figures were more readily available, we are again handicapped by the lack of detail, only yield per acre and total acreage being given.

If we are studying corn, for example, when was the crop planted, when did it first appear above ground, when were first leaves seen, when was it knee-high and waist-high, when did ears first appear, silking, tasseling, when in milk, dough, and early roasting-ear stages, when mature? Are there any answers to these important questions? Maybe, locally, at certain experiment stations or elsewhere, but are these records continuous for the same crop under the same cultural practices for 25 years, or more?

The problem at present is to account for the 40 per cent divergence between the predicted and actual yields. Assuming we have carried our study to the 0.90 coefficient mark, and that phenological data in sufficient detail are available for 25 years, what about weather data in corresponding detail? These should be available for at least the neighborhood of the growing crops. At most State experiment stations, unless unusually well equipped, there are maximum and minimum thermometers and a rain gage. These are read at about 4 p. m. or 8 a. m. and the maximum and minimum temperature, set maximum temperature, and total rainfall entered on forms. Where are the details? How much sunshine, what was soil temperature, when did rain occur, how long were temperatures above or below a significant value, what was the relative humidity, rate of evaporation, etc.?

Even if the above questions were satisfactorily answered how can we be sure that we have everything we need? Maybe we need leaf temperature, intensity of solar radiation, plant transpiration, moisture of the soil at different depths, and many other details too numerous to mention.

CONCLUSION

Are we doing everything possible to facilitate the study of crop production in its relation to the weather on a large scale, or even in local areas? There have been some beginnings. Some phenological studies have been made here and there, notably those of Thomas Mikesell, but only in very localized sections. The State weather and crop service of Iowa is at present engaged in collection of phenological data, but the records are still short. There are, at present, no known systematic researches being conducted of the direct relation of weather to crops under field conditions, where detailed weather and crop data are collected, side by side.

We breed high yielding corn, wheat, and oats, drought-resistant corn, rust-resistant wheat, etc., but too little is known of the effect of weather on crops in their various stages of development. We know hot, dry weather hurts wheat at heading time and corn when tasseling and some other generalizations, but that largely comprises the extent of our knowledge at present.

To enable us to know just how the weather is affecting a crop at any time, to forecast crops accurately, and to practice agricultural meteorology as a science and not as an art, we need accurate and comparable data of weather and of crop progress, with the details of various weather phases and of crop development from planting to harvest accurately observed and recorded on the ground.

TOR BERGERON'S ÜBER DIE DREIDIMENSIONAL VERKNÜPFENDE WETTERANALYSE[1]

By ERIK BJORKDAL

[Translated from German text by Andrew Thomson]

Translator's note.—This large and important work of 110 pages (31 by 23 centimeters) with 6 plates and 25 figures written by Doctor Bergeron of the Norwegian Meteorological Office at Oslo constitutes the most important recent summary of the technique of the Norwegian School of Meteorology.

Due largely to the absence of definite guidance on how to locate "fronts" on the weather map, considerable misunderstanding of polar front methods has arisen. Prof. J. Bjerkness's memoir[2] on Practical Examples of Polar Front Analysis, written in 1926, deals with specific cases of fronts passing over the British Isles, whereas Doctor Bergeron discusses the general principles of frontology equally applicable to Europe and to North America.

The following illuminating review by Doctor Bergeron's colleague indicates the field covered by Doctor Bergeron's extremely valuable and suggestive book which is marred for English readers by an involved style of sentence structure:

This work gives the first systematic exposition of the analytical methods of the so-called Bergen School of Meteorology. It discusses the existence and formation of tropospherical air masses and air separations, as well as their decisive importance for weather. Until further empirical investigations have been carried out the results hold only during the winter season over North America, north Atlantic, and western Europe.

The author first attacks the view which has often been advocated that the chief seat of pressure variations and weather changes may be sought in the substratosphere. He brings forward various plausible reasons for believing that the extratropical transformations of energy have their seat essentially in the troposphere and even in its lower half. There the weather actually displays itself.

The study of the structure of the troposphere is thus of fundamental importance. Already before the work of the Bergen meteorologists, various investigators had deserted pure isobaric geometry and realized there was a battle between air masses. But none of them was lead from their theoretical considerations to the daily weather map and no one realized that the boundary surfaces were entities of which the properties and dynamics

[1] Bergeron, T.: Ueber die Dreidemensional Verknüpfende Wetteranalyse, I. Teil. Geophys. Pub., Oslo, vol. 5, No. 6, 1928.
[2] Geophysical Memoir No. 50, British Meteorological Office, London, 1930.